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ABSTRACT

A study examined laterality effects observed in previous studies in which men as well as right-handers show a right-visual field (RVF) advantage for letter recall and a left-visual field (LVF) advantage for letter position recall, suggesting asymmetrical brain organization for these groups. Subjects, 96 undergraduates equally divided by sex and hand dominance, were required to recall either the letters or the respective letter positions within 4x4 matrices flashed to the right or the left visual field. Subjects further received instructions prior to each trial cueing them as to the field in which the matrix would be positioned. Results indicated that right-handed men demonstrated the predicted RVF advantage for letters while only right-handed subjects evidenced a LVF advantage for letter positions. Findings suggest that the instructions could have been contributing to the observed sex difference with letters, implying that right-handers exclusively possessed this asymmetrical organization. (Three tables of data are included and 28 references are attached.) (Author/RS)

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Further Evidence of Asymmetrical Processing of Tachistoscopic Inputs in Undergraduates Across Sex Handedness, Field-Side, and Fixation Instructions

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Summary

Past studies have indicated that men as well as right-handers show a right-visual field (RVF) advantage for letter recall and a left-visual field (LVF) advantage for letter position recall, suggesting asymmetrical brain organization for these groups. To examine these laterality effects more closely, 96 undergraduates were tested in a tachistoscopic task - being equally divided by sex and hand dominance. On each of the 48 trials, subjects were required to recall either the letters or respective letter positions within 4 x 4 matrices flashed to the right or left visual field for 100 msec. Subjects further received instructions prior to each trial cueing them as to which field the matrix would be positioned (i.e., left, right or neither). Analyses showed that right-handed men demonstrated the predicted RVF advantage for letters while only right-handed subjects evidenced a LVF advantage for letter positions. Instructions could have been contributing to the observed sex difference with letters, implying that right-handers exclusively possessed this asymmetrical organization.

Asymmetrical Processing of Tachistoscopic Inputs in Undergraduates Across Sex, Handedness, Field-Side, and Fixation Instructions

In tachistoscopic tasks, a right-visual field (RVF) advantage has often been found for letters and words while, conversely, a left-visual field (LVF) advantage has been reported for nonlinguistic stimuli, ranging from sets of dots to human faces (Bryden 1965; Ellis & Shepard, 1975; Kimura, 1969). These effects would suggest that the cerebral hemispheres are organized asymmetrically - with the left hemisphere more specialized for language and the right more critically involved with visuospatial components (Bradshaw & Nettleton, 1983).

However, more current research indicates that some women and left-handers possess a different type of cerebral organization. Levy (1972, 1976) theorizes that in these groups, language is bilaterally represented in both hemispheres. According to this bilateralization argument, no field advantage will be evidenced in women and left-handers when processing materials of a verbal nature. However, with spatial materials, scores will be depressed due to the right hemisphere handling verbal as well as nonverbal functions.

In confirmation of Levy's (1972) bilateralization theory,

certain tachistoscopic studies have shown some very strong field advantage differences in men, with a RVF advantage for letters and words (Bradshaw & Gates, 1978; Hannay & Malone, 1976; Marshall & Holmes, 1974) and an even more pronounced LVF advantage for elements oriented in a certain direction or positioned within a particular spatial arrangement such as a matrix (Davidoff, 1977; Kail & Siegel, 1978; Rizzolatti & Buchtel, 1977; Sasanuma & Kobayashi, 1978). Women, on the other hand, did not demonstrate these field differences; further, their recall of element positions was inferior to men's (Kail & Siegel, 1978), suggesting less lateralization of verbal and spatial functioning in this respective group.

When handedness was examined in other tachistoscopic assignments, visual field differences were also noted. Regardless of the information presented, left-handers did not show any field advantages while right-handers performed similarly to men (Bryden, 1973; Heller & Levy, 1981; Hines & Satz, 1971; Kinsbourne, 1973; McKeever & Gill, 1972; Zurif & Bryden, 1969). In further support of the bilateralization theory, a limited number of visual studies revealed that left-handed women were impaired when demonstrating spatial competencies, unlike their right-handed counterparts (Kail & Siegel, 1978; McGlone & Davidson, 1973; Sanders, Wilson, & Vandenberg, 1982). In summary, these findings would seem to

imply that certain subjects can handle linguistic functions in both hemispheres, but cannot effectively process spatial information (e.g., position and orientation) due to competing functions being performed by the right hemisphere.

Now Bryden (1978) has identified a possible confounding factor which may be contributing to this laterality effect in men and right-handers - attentional bias (i.e., the directed focus of atention to one side of the body). Though Bryden's work (1986) has mainly been in the dichotic listening area, some researchers (Hardyck, Chiarello, Dronkers, & Simpson, 1985) have attempted to apply this methodology to tachistoscopic presentations. In the Hardyck, et al. (1985) series of studies, subjects were instructed to attend strictly to one visual field and report if the items displayed on that side were actual words or not by pressing the appropriate button. Subjects were then required to shift their fixation to the unattended field side on alternating blocks of trials. Throughout the five experiments, a consistent pattern emereged: the predicted RVF advantage was obtained for word recognitions, but instructions to bias subjects' attention to the right side did not improve the overall accuracy of these identifications. Though Hardyck, et al. (1985) concluded that visual field differences in lexical decision tasks were not affected by atentional bias, we believe that more

tachistoscopic experiments involving different materials still need to be executed to determine more effectively if this factor could have any influence on laterality outcomes.

The present experiment, therefore, further investigated the interactive effects of sex, handedness, field-side, as well as fixation instructions on the processing of tachistoscopic information. Our predictions were 1) that performance symmetries would be most pronounced in left-handed women regardless of field-side or type of instructions received, with the lowest scores occurring for the recall of letter positions within matrix presentations; and 2) that field differences would be evidenced in right-handed men independent of instructions, with a right-visual field advantage for recall of letters and an even more pronounced left-visual field advantage for recall of the respective letter positions within the matrices.

Method

Subjects and Design

The subjects were 96 undergraduate students (M = 19.6 yr.) who received additional credit points in their introductory psychology and sociology classes for their voluntary participation. They were not preselected according to major or grade point average. There were 48 left-handers and 48 right-handers, with both groups divided equally according to

sex. Two between-subjects factors, sex (man, woman) and handedness (left-hander, right-hander) and two within-subject factors, visual field (left, right) and instructions (left-side fixation, right-side fixation, no-side fixation) were employed in 2 x 2 x 2 x 3 factorial designs which examined the ability to remember the identity and position of letters respectively within a square matrix.

Handedness Assessment

Annett's (1967) handedness questionnaire was used to determine the hand dominance of an undergraduate pool of subjects (N = 396) selected from psychology and sociology classes. The 12-item questionnaire asked subjects to judge which hand they used the most (left, right or either) across a wide range of manual activities (e.g., brushing one's teeth, writing a letter, unscrewing a jar, and throwing a ball). Employing Nagae's (1983) scoring procedure, we assigned a score of -1 to every left response that was provided by each subject, a score of +1 to every right response, and a 0 to every either response that occurred. Only those with the strongest hand preference (n = 96) participated in the main experiment. Each of the chosen group's mean hand dominance was as follows: 24 left-handed men = -10.52 (SD = 1.78), 24 left-handed women = -10.89 (SD = 2.11), 24 right-handed men = 10.61 (SD = 0.96), and 24 right-handed women = 10.24 (SD =

1.57).

Stimulus Materials and Apparatus

The tachistoscopic materials were 4 x 4 matrices, each containing five letters. These letters were selected randomly from a set of 20 consonants and were placed randomly in one of the 16 cells of each matrix, subject to the constraint that the letters not form a symmetric pattern within the matrix. Each of the square matrices was presented on a 5 - X 5 1/2 in. stimulus card.

As each matrix was shown in the respective visual field, one of three geometric figures (i.e., circle, star or triangle) was presented at the fixation point. The dimension of each figure was approximately .4 mm. and the outer edge of each matrix was situated .6 mm. from the fixation point, with letter size .4 mm. and overall matrix size 2.00 mm. Subjects' viewing distance from each stimulus card was approximately 11.00 mm., and a Lafayette electro-tachistoscopic shutter with automated timer (Model No. 40010) regulated subjects' duration of exposure to each card. Forty-eight stimulus cards were used, along with two practice cards for each recall condition.

Response booklets contained two types of pages. On the letter recall page, the three geometric figures shown at the fixation point appeared in a row, with the 20 consonants arranged alphabetically in two rows directly below the

figures. Subjects were required to circle the letters (and figure) which were just presented on the respective index card. On the position recall page, an empty 4 x 4 matrix appeared directly below the row of three geometric figures, and subjects were required to place X's in the appropriate cells where they thought the most recently viewed consonants had been shown. All these materials were derived from the Kail and Siegel (1978) experiment, except that consonants were used within the matrices instead of single-numbered digits.

Procedure

On each of the 48 trials, subjects looked at a geometric figure in the middle of the screen while a matrix was simultaneously presented in either the subjects' left or right visual field for a 100 msec. duration. All subjects received specific instructions prior to each trial: on 16 of the trials, they were informed that the matrix would be positioned in the right visual field; on another 16 trials, they were told the matrix would be situated in the left visual field; and on the remaining trials, subjects were not informed as to which field the matrix would be positioned. These sets of instructions were counterbalanced across trials. The experimenter further administered some general guidelines at the start of each trial which emphasized that subjects: a) look at the geometric figure at the central location, b) try

to recall that figure, and c) try to recall the letters or letter positions within the matrix.

Recall immediately followed each tachistoscopic presentation. Each subject was tested in two recall conditions: letter identity and letter position. For each condition, two practice trials had been provided beforehand to ensure that subjects were acquainted with the recall requirements. No time limit was placed on recall, though most subjects rarely needed more than 10 sec. to complete the recall page which either required circling the appropriate letters or placing X's in the appropriate positions within an empty square matrix. Guessing was encouraged, especially if subjects had difficulty discriminating the letters (e.g., b from d, m from n). The next trial began as soon as each subject completed the appropriate page.

Order of the recall conditions was counterbalanced across type of instructions (i.e., left-field knowledge, right-field knowledge, no-field knowledge), with a total of 24 trials examining recall of letters and the remaining 24 testing recall of letter positions. The total number of letters that were identified correctly for each subject was subsequently obtained and incorporated in a mixed factorial analysis. The same procedure was performed for position recall, with the total number of correct identifications being tabulated for

each subject and then analyzed by a second mixed factorial design.

Results

Letter Recall. The 2 x 2 x 2 x 3 (sex x hand x field-side x instructions) analysis of variance performed on correct letter recognitions gave the following main effects: sex ($F_{1,93}$ = 10.09, MSe = 2.98, $p < .01$), handedess ($F_{1,93}$ = 20.45, MSe = 2.98, $p < .01$), field ($F_{1,186}$ = 12.37, MSe = 2.14, $p < .01$), and instructions ($F_{2,186}$ = 10.38, MSe = 2.14, $p < .01$). Men identified more letters correctly than women, with respective Ms (and SDs) = 15.83 (1.83) and 15.30 (1.94); right-handers performed better than left-handers, with Ms (and SDs) = 16.81 (1.85) and 14.32 (2.01); letter recognitions were better in the right visual field than the left, with Ms (and SDs) = 15.93 (1.89) and 15.19 (1.92); and instructions to fixate on the right side unexpectedly generated the greatest number of correct responses (M = 15.88 and SD = 1.50) in comparison to ones directed to the left side or to no specified side, with respective Ms (and SDs) = 15.35 (1.90) and 15.45 (1.55).

A number of significant two-way interactions were also obtained in the letter analysis. The interaction of sex x hand ($F_{1,93}$ = 17.14, MSe = 2.03, $p < .01$) showed that right-handed men performed the best out of any of the groups (M = 18.12). Scheffé post hoc testing further indicated that

left-handed men generated the lowest recognitions (M = 13.53) while the female hand groups elicited comparable performances (with the right and left hand Ms = 15.49 and 15.11).

With respect to field differences, the interaction of hand x field ($F_{1,93}$ = 15.66, MSe = 2.03, $p < .01$) indicated that right-handers exhibited a right-field advantage for the letters (M = 17.61 in comparison to the left field M = 16.00). This pattern was not reflected in left-handers' scores upon multiple comparison testing. The significant interaction of sex x field ($F_{1,93}$ = 11.70, MSe = 2.03, $p < .01$) also confirmed that a right-field advantage existed for men (M = 16.62 in comparison to the left field M = 15.03). Similar to the results with left-handers, women did not evidence these field differences.

Some unpredicted interactions involved the fixation instructions. The field x instructions interaction ($F_{2,186}$ = 6.28, MSe = 1.65, $p < .01$) demonstrated that the best identifications occurred in the right visual field when subjects were told to fixate on that side (M = 16.64). Scheffé comparisons showed further that the worst performance was in the left-field, left-fixation condition (M = 15.15). Moreover, instructions had an effect on tachistoscopic performance in men, as evidenced by the significant interaction of sex x instructions ($F_{2,186}$ = 5.62, MSe = 1.65,

$p < .01$).

Insert Table 1 about here

As presented in Table 1, men recognized the most letters correctly when instructed to fixate their attention on the right side ($M = 16.53$). Women's identifications were not affected by the type of fixation instructions and were consistently comparable to men's scores in the other conditions. It should be noted that these interactions with instructions were inconsistent with the Hardyck, et al. (1985) findings involving word recognitions.

Though instructions produced strikingly differential effects between the sexes, the remaining significant interaction did not include this variable. The sex x hand x field interaction ($F_{1,93} = 5.67$, $MSe = 1.96$, $p < .05$) reflected a recognition difference between fields, but only for right-handed men.

Insert Table 2 about here

As Table 2 depicts, a right-field advantage existed for these subjects solely, confirming one of our original predictions. The correct identification averages for right and left fields

were 19.72 and 16.53, respectively. Once again, women's scores did not show these field differences and were comparable across hand groups upon Scheffé testing. Left-handed men had the lowest recognitions regardless of field-side (with the right and left field Ms = 13.51 and 13.54), suggesting not all groups were able to effectively process the letter materials. Whether this same pattern would hold true for the letter postion elements was determined by the next analysis.

Letter Position Recall. A second 2 x 2 x 2 x 3 (sex x hand x field x instructions) analysis of variance examined differences in subjects' recall of the matrix letter positions. As hypothesized, all main effects except instructions were significant: sex ($F_{1,93}$ = 8.02, MSe = 2.26, $p < .01$), handedness ($F_{1,93}$ = 12.46, MSe = 2.26, $p < .01$), and field-side ($F_{1,93}$ = 11.98, MSe = 1.09, $p < .01$). Men performed better than women, with respective Ms (and SDs) = 18.62 (1.76) and 18.06 (1.85); right-handers identified more letter positions correctly than left-handers, with Ms (and SDs) = 18.07 (1.69) and 16.90 (1.98); and position identifications were better in the left visual field than the right, with Ms (and SDs) = 17.84 (1.84) and 17.13 (1.95). Instructions to fixate on a specific side apparently did not produce response differences as they had in the letter recall

analysis. Moreover, any interaction involving instructions did not reach significance, suggesting that position identifications were not influenced by attentional bias. These findings were consistent with those obtained by Hardyck, et al. (1985).

While instructions did not contribute to a laterality effect, handedness did as evidenced by the significant interaction of hand x field ($F_{1,93}$ = 8.77, MSe = 1.32, p < .01).

Insert Table 3 about here

As predicted, right-handers showed a left-field advantage for the letter positions upon Scheffé testing (M = 18.66 in comparison to the right field M = 17.48) while left-handers did not demonstrate this field difference, similar to the pattern obtained with the letter stimuli (see Table 3).

Unlike the previous analysis, any interaction involving sex failed to reach significance, implying that men processed the position inputs differently form the letters. Further, the noninteraction of sex x instructions could have possibly accounted for the similar field performances in both men and women (and this explanation will be discussed in more detail shortly). In contrast, the left-field advantage in

right-handers was not influenced by sex or instructions and clearly indicated that a laterality effect could occur independently within a specific group of subjects.

Geometric Figure Recall. Four-way analyses of variance were also performed to determine if there were any differences in recall of the geometric figures presented at the subjects' fixation point. For the letter analysis, a main effect of instructions was observed ($F_{2,186}$ = 9.69, MSe = 1.14, $p < .01$), signifying that subjects were able to identify more figures corrctly when not required to focus onto a certain field (M = 9.05 and SD = 1.53) than when directed to focus on the left side or the right, with respective Ms (and SDs) = 6.68 (2.35) and 6.85 (2.10). A similar effect for instructions occurred in the positon recall analysis ($F_{2,186}$ = 5.73, MSe = .78, $p < .01$), with subjects once again performing better without field-specific instructions (M = 10.77 and SD = 1.94) than with left- or right-side directions, with respective Ms (and SDs) = 9.56 (2.16) and 9.67 (1.77). It would appear that the field instructions disrupted recall of the geometric figures regardless of the side or test condition, suggesting that a "performance trade-off" existed between letter (or position) identifications and the figures.

Discussion

Though our original predictions were not fully supported,

two findings are of interest in this study. First, women and left-handers did not show any field advantages for either letters or letter positions. Right-handers, on the other hand, demonstrated some very definite field differences, exhibiting a right-visual field advantage for letters in the male members exclusively and a left-visual field advantage for the letter positions (which was independent of the subject's sex). These performance differences replicated the sex and most especially the handedness effects obtained in previous tachistoscopic designs (Bradshaw & Gates, 1978; Bryden, 1973; Heller & Levy, 1981; Kail & Siegel, 1978; Kinsbourne, 1973). The questions that can then be raised are: 1) What is contributing to the laterality effect in right-handers? and 2) Why is this effect stronger for right-handers than for men?

Answers to both questions can be derived from the second major finding involving instructional bias (i.e., directed fixation to a particular field). In the letter analysis, a sex x instructions interaction was found, showing that men performed better in the right-side focus condition. This interaction could have been contributing to the laterality effect evidenced in the male group. Right-handers, however, were unaffected by the instruction conditions, indicating that a different mechanism was responsible for their field advantage. We propose that right-handers possess a more

asymmetrical cerebral organization than left-handers, with their left hemisphere being more specialized to process linguistic inputs such as letters and even dichotic sounds (see Iaccino & Sowa, 1988). Sex groups probably do not have this type of hemispheric organization, and so any processing differences shown (especially in men) are more reflective of task requirements, in this case the shifting of the 'attentional set' from the left side to the right. This hypothesis might also explain why Hardyck, et al. (1985) did not obtain a stronger RVF advantage when instructions were manipulated. Perhaps their subjects had difficulty executing this attentional shift from one side to the other.

Our argument is even more compelling when one interprets the results of the letter position analysis. Sex did not interact with instructions here, and so the predicted left-visual field advantage did not occur in men. On the other hand, right-handers who were uninfluenced by the instructional conditions continued to demonstrate processing differences between visual fields, replicating the letter analysis findings. Therefore, we claim that the field advantages in right-handers for letters and letter positions can be accounted for primarily by physiological differences between the cerebral hemispheres while any field advantages in men can be more adequately explained by shifting attentional

strategies required within the study itself. In light of these findings, it would seem that Levy's (1972) bilateralization theory is only applicable to hand groups and not sex type, as previously proposed.

The instructional bias effects on sex do, however, support Kinsbourne's (1975) attentional model which suggests that an adopted categorical set for letter stimuli will bias the subject's attention to the right side (as was evidenced with men in our study) while another set for nonverbal elements will bias the attention to the left. Since the left-side bias was not shown for positions in our male group, we can only speculate that there might have been difficulty in employing a specific attentional strategy with such nonlinguistic materials. It should also be noted that field-instruction conditions disrupted recall of the geometric figures, further indicating that subjects experienced problems in effectively distributing their focus from the directed field back to the center of the screen where the figures were located. At this point, we can only state that instructional bias does exert some effect on men's tachistoscopic performance as in dichotic listening (Iaccino & Sowa, 1988). Whether this variable has any influence on right-hander's performance in tachistoscopic tasks still needs to be determined by way of further attentional manipulation.

Based on these overall results, we have adopted the view that not all subjects will be processing tachistoscopic information in the same manner. Right-handers will be bringing their asymmetrical "blueprint" into the laboratory, males will be utilizing a specific attentional set for certain kinds of materials, while left-handers and women will be introducing some other component (as yet to be identified) into the task. Whether this component will assist these latter subjects is questionable, since their tachistoscopic identifications were found to be considerably lower than the other groups. Research should be directed toward finding these unknown factors (if they exist) as well as reliably confirming those already identified so that a better understanding of how subjects process tachistoscopic and other nonverbal inputs can be achieved.

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Table 1

Average Number Correct Letter Identifications as a Function of Sex and Fixation Instructions

		Fixation Instructions					
		Left		Right		None	
Sex	n	M	SD	M	SD	M	SD
Men	48	15.29	1.86	16.53	1.42	15.66	1.53
Women	48	15.41	1.92	15.23	1.67	15.26	1.54

Table 2

Average Number Correct Letter Identifications as a Function of Sex, Handedness, and Visual Field

		Visual Field			
		Left		Right	
Sex	n	M	SD	M	SD
Men					
Left-Hand	24	13.54	2.08	13.51	1.87
Right-Hand	24	16.53	1.72	19.72	1.85
Women					
Left-Hand	24	15.22	2.13	15.00	2.01
Right-Hand	24	15.47	1.86	15.50	1.88

Table 3

Average Number Correct Position Identifications as a Function of Handedness and Visual Field

		Visual Field			
		Left		Right	
Hand	n	M	SD	M	SD
Left	48	17.02	1.96	16.78	2.04
Right	48	18.66	1.63	17.48	1.72